

## SECTION III.—FORECASTS.

## FORECASTS AND WARNINGS FOR NOVEMBER, 1916.

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Of the LOWS that appeared on the weather maps of the United States during November, six were of the Alberta type, five the North Pacific, one South Pacific, one the Northern Rocky Mountain region, two Colorado, and one of tropical or West Indian type. In all there were 17 and there was no uniformity with respect to their speed and direction of movement.

Of the HIGHS that made their appearance during November, 14 in number, 2 first appeared over the western Canadian Provinces, 4 over the Rocky Mountain region, 2 off the North Pacific coast, 4 off the South Pacific coast, and 2 north of the Great Lakes and St. Lawrence Valley. The most important of the HIGHS was that which appeared over Alberta, Canada, on the 10th and advanced thence in a southeasterly direction attended by severe cold in nearly all parts of the United States. On the 9th, in advance of the appearance of this cold wave, the following special bulletin was issued and disseminated:

Disturbance now in the Northwest will advance southeastward and be followed by a pronounced change to colder weather within the next 36 to 48 hours in the northern Rocky Mountain region and Northern Plains States, and by Saturday the 13th, in the upper Mississippi Valley. The cold weather will be of several days' duration in these regions.

The disturbance of most pronounced character was the one which appeared in the southwest on the 20th and 21st and moved northeastward across the Great Lakes where it was attended by shifting gales. Whole-gale warnings were displayed well in advance of the dangerous winds, and as a result no marine disasters occurred on the Great Lakes. Commenting on the warning, an editorial in the Times of Buffalo, N. Y., of December 1, reads as follows:

Now that navigation is practically over for the season of 1916, one looks back with pride to the enormous amount of traffic on the inland seas. Considering the few marine disasters and the comparatively small loss of life in connection with handling the gigantic fleet on the Great Lakes during the past season, one can but commend the excellent service rendered by the Weather Bureau, and especially so with reference to the severe storm that passed over the Lake region November 23 and 24, for which Prof. Charles F. Marvin, Chief U. S. Weather Bureau, issued the following warning:

"WASHINGTON, D. C., November 23, 1916.—Change to whole-gale storm warning, 10 a. m., Lakes Michigan, Huron, and Erie, and hoist whole-gale warning on Lakes Superior and Ontario. Storm central over southern Lake Michigan increasing rapidly in intensity and moving northeast will be attended by shifting gales and rain, changing to snow. Dangerous conditions. Advise vessels to remain in port."

This was the first instance since the adoption of the Beaufort scale that a whole-gale storm warning was issued for the Lake region. The warning was so thoroughly distributed throughout the Great Lakes that not a vessel left port until after the severe gale subsided. The absence of wrecks or loss of life is evidence that the marine interests generally heeded the strong warning issued by the Chief of the Weather Bureau for all ships to remain in port.

And this is only one of many instances where the Weather Bureau, during the past year, has rendered the public great service.

The Free Press of Detroit, Mich., of November 26, stated:

Vessel men in Detroit and in other lake ports were congratulating each other Saturday over the fact that there apparently was no loss of life or vessel property in the severe gale that beat the lakes Thursday and Friday, with the one exception of the new Standard Oil Company barge No. 82, which was wrecked Friday on Grenadier Island, Lake Ontario, near Kingston, Ontario, after her anchor chain parted.

To the general observance of safety first principles rather than to any favoring of daring navigators by good fortune, is credited the fact

that the lake fleet seems to have come through the hurricane period unscathed and without decimation.

The circumstances, previously deplored, that many of the freighters were being held in ports at the head of the lakes by slow loading of frozen ore, and in ports on Lake Erie by shortage of cars for handling their cargoes, may have been an important factor in averting perils for many of the vessels, as it was possible to immediately inform them of threatening atmospheric conditions, when the Weather Bureau gave warning of the approach of a storm of full-gale intensity, Thursday forenoon.

Others were warned by radio stations. A large number of ships in transit were held in the rivers above and below Lake Huron to await developments. As many as 27 were counted in Detroit River Friday, while 44 were lying in the vicinity of Port Huron and other large fleets lay above and below Sault Ste. Marie, in the straits of Mackinac and in various other sheltered spots.

With all the crowding of freighters in Detroit River, only one accident was reported. The new Norwegian steamer *Thorngerd*, just completed at Port Arthur and on her way to the Atlantic without cargo, swung in the channel near Grassy Island and stuck her stern on the bank. She was pulled off early Saturday morning by the tug *A. W. Colton* of the Great Lakes Towing Co., and was reported passing down through Livingstone channel about 6:30 o'clock Saturday night.

The tropical disturbance referred to made its appearance on the 12th over the Caribbean Sea east of Honduras, moved thence in a northwesterly direction through the Yucatan Channel; it recurved over the southeastern portion of the Gulf of Mexico and advanced northeastward over extreme southern Florida during the 15th and passed eastward over the Bahamas. This disturbance, according to press reports, did considerable damage to property along the coast of Honduras and in Yucatan.

## GENERAL PRESSURE DISTRIBUTION.

Over the Alaskan area the pressure was below the normal at nearly all stations from the 1st to 7th, decidedly above the normal during the 8th to 13th, and below the normal thereafter to the end of the month except from the 21st to 24th, inclusive. In the vicinity of the Hawaiian Islands the pressure was above the normal from the 1st to 8th, and 16th to 28th, inclusive, and below the normal at other times during the month. In the vicinity of Bermuda, the pressure was below the normal during the 1st to 4th, and 16th to 20th, inclusive, and above the normal on all other days during the month.

## DISTRICT WARNINGS DURING NOVEMBER.

*Washington district.*—At the beginning of the month the pressure was low over the western Caribbean Sea and high in the Atlantic States, a condition that persisted during several days, but no well-defined disturbance developed within the area of low pressure over the Caribbean Sea. Advisory notices of strong winds, however, were necessary for the Florida Straits and adjacent waters. The night of the 5th, when a disturbance of marked intensity was central north of Montana, advisory information to the effect that strong southerly winds would prevail was sent to stations on the Upper Lakes and storm warnings were displayed on western Lake Superior, and on the morning of the 6th the display of warnings was extended to cover Lakes Michigan, Huron, and eastern Lake Superior. The disturbance moved northeastward toward Hudson Bay attended by strong southerly winds on the upper Lakes, but they were not of sufficient force to interfere with navigation.

On the 7th a disturbance made its appearance over the southern Rocky Mountain region and moved northeastward, crossing the Great Lakes on the 8th and 9th. Advisory information covering this disturbance was sent

to Great Lakes stations on the 7th and later southwest storm warnings were ordered for the lower Lakes, where winds of moderate gale force occurred on the 9th.

The disturbance over the Great Lakes moved down the St. Lawrence and the morning of the 9th southwest storm warnings were displayed on the Atlantic coast at and north of Delaware Breakwater; the display was followed by south to west gales during the afternoon and night of the 9th over the region where warnings were displayed. This disturbance was followed quickly by a secondary disturbance on the Great Lakes, and the afternoon of the 10th southwest storm warnings were again displayed on Lakes Erie and Ontario and were followed by westerly gales during the night of the 10th. The highest velocity, 68 miles an hour, occurred at Buffalo, N. Y.

On the 8th and 9th announcements were made of fresh easterly gales for the Yucatan Channel, Cuban waters, and the southeastern portion of the Gulf of Mexico, when, strong pressure gradients were in evidence in these regions, and there were indications of a disturbance to the west of Jamaica. The winds of gale force occurred as forecast, but the disturbance over the Caribbean Sea did not gain more than moderate intensity.

On the evening of the 11th when there were some indications of the development of a disturbance in the central Mississippi Valley, northeast storm warnings were displayed on Lakes Michigan and Huron, and during the 12th and 13th strong easterly winds and snows occurred on these lakes, although at no station did the wind reach gale force.

Reports from the West Indies on the 13th showed unmistakable signs of a disturbance over the western Caribbean Sea and information was issued as follows:

Hoist northeast storm warning 10 a. m., southern Florida coast, Tampa to Jupiter Inlet. Disturbance central in the vicinity of Swan Islands, increasing in intensity, will move northward attended by strong shifting winds, probably of gale force over the east portion of the Gulf of Mexico, southern Floridan, and Cuban waters.

The afternoon of the 13th northwest storm warnings were displayed on the gulf coast from Bay St. Louis, Miss., to Cedar Keys, Fla. The tropical disturbance moved northward as forecast and reached the east Gulf of Mexico the morning of the 15th, where it recurved and passed northeast across the Florida Peninsula during the afternoon of that day. This disturbance was attended by gales over the Gulf of Mexico and adjacent waters, the highest velocities reported being 52 miles an hour at Key West and 64 miles an hour at Habana during the night of the 15th, and also off the Atlantic coast as far north as Cape Cod. Shipping in the regions where the gales occurred was fully advised concerning the expected gales, and so far as known no wrecks occurred.

The disturbance of greatest intensity to influence weather conditions in the Washington district in November was of the Texas type and formed in the Rio Grande Valley. Its center on the morning of the 22d was over Arkansas, on the morning of the 23d over Lake Michigan, and on the morning of the 24th over the St. Lawrence Valley. Storm warnings were displayed in connection with this storm on the Great Lakes and on the Atlantic and east gulf coasts and winds of gale force occurred generally over the regions where warnings were displayed. On the morning of the 23d when the center of this disturbance was over southern Lake Michigan, the storm warnings already displayed were changed to "whole gale or hurricane" warnings, and subsequently the Great Lakes were subjected to gales and snow that arrested navigation generally, yet because of the timeliness of the warnings no loss of shipping occurred on any of the Lakes.

Southwest storm warnings were displayed on the lower lakes on the 26th when a disturbance was central near Lake Superior, and, while strong winds occurred on these lakes and on Lakes Michigan and Huron, the storm was not dangerous.

Frost warnings were issued on a number of days for the east Gulf States and the Florida Peninsula, except the extreme south portion, and in nearly all instances frosts or freezing temperatures occurred as forecast. There was but one cold wave of importance during the month in this district. It made its appearance in the Northwest on the 10th and 11th and advanced thence eastwardly and overspread the region east of the Mississippi River during the 13th to 16th. Cold-wave warnings were ordered well in advance of this cold change which carried the line of freezing temperature southward to the middle Gulf coast and northern Florida.

*Chicago district.*—The first cold-wave warnings of the season were issued on the 9th. The morning reports of that date showed a marked decrease in pressure throughout the Northwestern States and a decided increase over Alaska and southeastward to British Columbia, indicating that the disturbance then centered just north of Montana would move rapidly southeastward and be followed by a strong area of high pressure from Alaska.

A forecast of "much colder" was incorporated in the regular morning forecasts for all States west of the Mississippi River, except Missouri, the period being extended to cover 48 hours in most cases. In addition, the central office issued a special forecast covering a pronounced fall in temperature expected in the trans-Mississippi region within the next 48 to 60 hours and stating that the cold weather would continue for several days. While the p. m. reports of the 9th did not show any low temperatures in the western Canadian Provinces, the 12-hour changes in pressure were such as to indicate a decided fall within the next 24 hours throughout the Northwest. Accordingly, cold-wave warnings were issued for Wyoming, eastern Montana, the Dakotas, and the northwestern portions of Minnesota and Nebraska. The following morning warnings were extended to include the remainder of Minnesota and Nebraska, except extreme southeastern Nebraska, northwestern Iowa, and western and central Kansas, the remainder of Kansas being included in warnings issued on the night of the 10th. These warnings were fully verified, except in the eastern portions of Kansas and Minnesota and northwestern Iowa. The cold wave gradually increased in severity in the northern Rocky Mountain region and Northeastern Slope until the morning of the 13th, when the lowest November temperatures of record were registered in Wyoming and western South Dakota, Sheridan, Wyo., reporting a minimum of  $-26^{\circ}\text{F}$ .

The only other warnings during the month were issued on the morning of the 23d. A disturbance of marked intensity was centered near Chicago moving northeastward, while a high-pressure area of considerable strength was advancing southeastward over British Columbia and Alberta, although no low temperatures were reported, except at Kamloops and Barkerville. Inasmuch as both the storm and the high-pressure area were expected to gain in strength, cold-wave warnings were issued for eastern Montana, Sheridan, Wyo., North Dakota, northern South Dakota, and northwestern Minnesota. The warnings were verified, and in addition, verifying temperatures were reached in southwestern South Dakota and northwestern Nebraska.

The great value of regular reports from Barkerville, Triangle Island, and Prince Rupert in connection with forecasts and warnings issued for the northern Rocky

Mountain region and northwestern States was specially emphasized on both occasions when cold-wave warnings were issued for those States during November.—*Chas. L. Mitchell, Assistant Forecaster.*

**Denver district.**—The month was marked by unusual conditions. Instead of the practically stagnant pressure distribution so common in November, the month was characterized by a rapid succession of high and low pressure areas, remarkably low temperatures in practically all parts of the district and much more than the usual variability in temperature. On the morning of the 10th a low-pressure area was central in eastern Colorado, with loops of the depression extending northwestward over Wyoming. High pressure overlay Montana and the Canadian Northwest, but there were no indications of the development of unusual cold, nor of the filling in of the western part of the low pressure in the central Rocky Mountains. During the following 12 hours the increase in intensity and magnitude of the anticyclone was marked and temperatures continued falling throughout northern districts. Cold-wave warnings were issued for eastern Colorado, it now being clear that the front of the anticyclone would move southward along the eastern Rocky Mountain slope. The warnings were fully verified. On the morning of the 11th warnings for southeastern Colorado were repeated together with warnings for northeastern New Mexico. The warnings were verified. On the morning of the 12th low pressure still occupied western Colorado, western New Mexico, and Arizona, and 12 hours later the low was central in western New Mexico. Cold-wave warnings were issued for southwestern Colorado, northern and eastern New Mexico, and northeastern Arizona, despite the fact that the eastward movement of the depression was blocked by the anticyclone on the southeastern slope. The warnings were fully verified, except in extreme southwestern Colorado. At Grand Junction the temperature reached 6°F., the lowest of record for November. Beginning with the morning of the 13th and continuing till the 29th warnings of frost for south-central and southeastern Arizona were issued almost daily. During the greater part of this period a ridge of pressure overlay New Mexico and the region northwestward. Frosts and freezing temperatures were of practically daily occurrence in this part of Arizona.—*Frederick H. Brandenburg, District Forecaster.*

**New Orleans district.**—Small-craft warnings were issued on November 7 for the Texas coast and on November 8 from Galveston to Corpus Christi, Tex., because of a depression of more than moderate intensity, moving from New Mexico eastward over Texas. The warnings were justified.

On November 8, a trough of low pressure, extending southwestward from the lake region to Texas, was attended by high temperatures over most of the district. An area of high pressure was central over the middle Pacific Coast States and the Plateau region, preceded by abnormally low temperatures. Freezing was forecast for northwestern Oklahoma and the Texas Panhandle and frost in the northern and western portions of western Texas. The warning was completely verified, temperatures of 30° to 34°F. prevailing over the area indicated.

Freezing temperatures were forecast for the northwestern portion of the district on November 9 but failed because of the rapidly developing depression from western Canada, which on November 10 formed a trough of low pressure over the upper Mississippi Valley and the southern Plains States.

On the morning of November 10, a cold-wave warning was ordered for the Texas Panhandle because of a high

pressure area of considerable magnitude over British Columbia. This warning was verified, the temperature at Amarillo falling from 52° at 8 p. m. on November 10 to 24° at 8 p. m. on the 11th. The anticyclonic area moved southeastward, attended by very cold weather over the northern Rocky Mountain region, with a steep pressure gradient southward to an area of low pressure over the southern Rocky Mountain region. At 8:20 p. m. on the 10th cold-wave warnings were ordered for western Oklahoma and were repeated the next morning and extended to include northeastern Oklahoma and the extreme northwestern portion of east Texas. Freezing weather was forecast for Oklahoma, northern and western Arkansas, and northwestern Texas as far as Abilene. The cold area did not advance with sufficient rapidity to cause freezing in Arkansas, but freezing weather prevailed on the morning of November 12 over nearly all of the remainder of the indicated area. The cold-wave warning for Oklahoma and the extreme northwestern portion of East Texas, and a cold-wave warning issued on the 8 p. m. map of the 11th for Fort Worth and Dallas, failed of complete verification because of the slow southeastward movement of the cold area. The high-pressure area continued to move southeastward on the 12th and 13th, but not rapidly enough to verify frost warnings for the interior of Louisiana nor for the greater portion of Arkansas; but freezing temperatures were recorded in eastern Oklahoma.

Cold-wave warnings were ordered on the morning of the 13th for Palestine, Tex., and southern Texas, except the extreme west coast. Freezing weather was predicted to extend also to northern and central Arkansas, and northwest storm warnings were issued for the Galveston section. Special observations, which were called for, showed that the high pressure area was beginning to move more rapidly, and at 1:40 p. m. on the 13th cold-wave warnings were issued for Louisiana and eastern and southern Arkansas, while the northwest storm warnings were extended to include the entire Texas coast. The sugar and trucking interests of Louisiana were warned to expect freezing temperatures by the morning of Wednesday the 15th, and these warnings were made emphatic and given wide distribution. The warnings issued on this date were successful. Northwest storm warnings were ordered for the Louisiana coast on the 13th at 9 p. m. and were ordered continued on the 14th, and were fully justified by conditions off the middle Gulf coast.

The cold-wave warning for Louisiana was repeated at 8:30 p. m. on the 13th and for southeastern Louisiana at 9 a. m. on the 14th—temperatures of 22° to 26° in the northern portion of the sugar and trucking region and 26° to 30° in the southern portion being forecasted to occur on the following morning. The cold-wave and temperature forecasts were verified, and the warnings enabled sugar growers to save most of their seed cane and to expedite windrowing. Because of the warnings a large amount of sugar cane was cut before the freeze and much of the matured truck was gathered. Temperatures of 24° to 30° were predicted for the sugar and trucking region of Texas, and were generally attained. The southern portion of the high-pressure area was over Texas on November 15, and it was necessary to repeat the low-temperature predictions for Louisiana and to give warnings of freezing in the sugar and trucking region of southern Texas. These forecasts were successful, temperatures being in some places in Louisiana 1 or 2 degrees lower on the morning of the 16th than on the preceding morning. Frost to the coast was forecast on the 16th for Louisiana, and the warning was justified.

With high pressure and cool weather over the southwestern portion of the country on the 18th, frost to the coast in Louisiana, and frost nearly to the coast in east Texas were forecast and conditions on the following morning showed that the warnings were justified.

The temperature was high in Arkansas on November 21 and an area of high pressure over the Rocky Mountain region threatened much colder weather. The low pressure area, however, which was developing over southern Texas, gained unexpected strength on the following day and extended its influence farther westward than was anticipated, and a cold-wave warning ordered for Bentonville, Ark., failed of verification. Freezing was predicted for Oklahoma and the northern portion of western Texas but the temperatures did not reach freezing in eastern and southern Oklahoma.

On account of the development of the disturbance over southern Texas, as indicated by the 8 p. m. map of the 21st, northwest storm warnings were ordered on the Texas coast. The winds increased but did not reach gale velocity. The disturbance was over the lower Mississippi Valley on the 22d and conditions on the Louisiana coast, as shown by a special observation from Burrwood, were such as to make advisable a small-craft warning ordered at 2:15 p. m.

On November 22 and 23, with a high pressure area moving eastward over the Rocky Mountain region and extending southward over Texas, frost was predicted for the southern portion of east Texas nearly to the coast and frost temperatures were recorded. On the 24th, freezing nearly to the coast and temperatures of 30° to 34° in the sugar and trucking regions were forecast for southern Louisiana and southeastern Texas. Predicted temperatures occurred in the Louisiana sugar and trucking region, and the conditions in Texas were evidently similar. Freezing temperatures, or lower, occurred generally in other portions of the forecast district as predicted.

On November 25, heavy frost to the coast, with temperatures of 28° to 32° in the sugar and trucking region of Louisiana, and frost in the southeastern portion of eastern Texas nearly to the coast, were successfully predicted. On the 30th was forecasted frost to the Louisiana coast and in the southeastern portion of eastern Texas except in the lower Rio Grande Valley and on the coast, and occurred as predicted.

On November 3 a special forecast of fair weather for the three following days was issued at 8:20 p. m. for the Shreveport State Fair, and was verified.

Fair-weather warnings were issued for western Oklahoma on the 5th, 8th, 11th, 13th, 21st, and 26th, and for Arkansas on the 5th, 6th, 7th, 8th, 11th, 13th, and 27th. They anticipated wind velocities of more than 15 miles an hour, with a statement of the wind direction and character of weather indicated. In some cases these warnings were for a period of 48 to 56 hours but most were for the following day. Conditions occurred generally as forecast except that in a few instances the weather forecasts were not verified.—*R. A. Dyke, Assistant Forecaster.*

*Portland (Oreg.) district.*—November opened with a low-pressure area over Alaska, causing rains in western Washington that gradually overspread the district and continued quite generally, until the 9th when clearing weather set in due to the southeastward advance of an extensive high pressure area from northern Alaska. On the night of the 10th–11th, this high lay over the eastern slope of the northern Rockies and the Plains States, and an unusual fall in temperature occurred over the Northwest. Killing frosts occurred on the Washington coast

on the mornings of the 11th and 12th, and the lowest temperatures of record were reported from southern Idaho from the 11th to 13th, and from the Umpqua Valley, Oreg., on the evening of the 12th. This drop in temperature reached the proportions of a cold wave over southern Idaho, a 24-hour fall of 36° having occurred at Pocatello by the morning of the 11th. The meteorological conditions preceding the cold wave were not expected to cause such a decided temperature fall, for it was thought that northeast winds crossing the Rocky Mountains and heating slightly adiabatically would prevent a marked fall, but the extent and intensity of the high were underestimated. A portion of the high pressure area, with attendant low temperatures, settled over the inter-montane region and fair weather with cold easterly winds continued until the 22d, broken only on the 18th when rains fell generally west of the Cascade Mountains and rain or snow in eastern portions of Oregon and Washington. A moderate cold wave forecasted for the 23d did not occur due to the effect of a rapid decrease in pressure along the North Pacific coast—the greatest 24-hour temperature fall reported having been 12° at Baker, Oreg. On the 28th a high-pressure area moved rapidly from the southern Oregon-California coast to the Plateau region and unusually rapid radiation caused a close approach to a cold wave over southeastern Idaho, for which cooler weather had been forecast.

Precipitation occurred in many portions of the district from the 25th to the 28th; a heavy fall occurred west of the Cascade Mountains.

General storm warnings were ordered on the 3d, 4th, 5th, and 27th, two were fully verified, one partially, and the one on the 5th was not. Warnings for part of the coast were ordered on the 2d, 9th, 17th, 21st, 24th, 26th and 29th; three were partially verified, and those on the 9th and 17th were not. Verifying wind velocities occurred on the 1st at North Head and Tatoosh Island, on the 8th at Seattle and Tacoma, and on the 21st at Seattle, without warnings having been issued, but we have learned of no resulting damage. Small-craft warnings were issued on the 5th, 8th, 14th, 15th, 16th, 17th, 21st, 25th, and 29th, all justified.

Frost warnings were not issued during November.—*T. Francis Drake, Assistant Forecaster.*

*San Francisco district.*—Southeast storm warnings were ordered from Point Reyes to Eureka on the 5th and 25th, and were partially verified.

The feature of the month was the period of cold weather with freezing temperatures and killing frosts from the 13th to 18th. Warnings of killing frost were issued on the morning of the 12th, and daily thereafter during the cold period. In some sections the growers were not prepared to protect their crops and serious injury resulted. The greatest damage occurred in the lower Sacramento and San Joaquin valleys, where minimum temperatures of 22° and 23° occurred. On the mornings of the 13th–15th, the temperature remained below 30° F. for several hours, and it was at this time that the greatest damage was done. In many sections vegetables and olives were killed and in some, citrus fruit experienced a heavy loss. The citrus groves located on the sidehills and where free air drainage obtained, experienced but little or no damage, while the groves in the low flat lands met with severe loss.—*G. H. Willson, District Forecaster.*

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*A special chart showing the hurricane tracks of the season of 1916 will appear in the December issue of the MONTHLY WEATHER REVIEW.*